AFEL - Glossary

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Aim and Purpose

The aim and purpose of this glossary is to facilitate understanding between the involved partners in the AFEL project. Therefore, we use this space to define key terms that are important for the research and development projects within AFEL. Whenever possible, we link the entries to the more detailed and elaborated discussion of these topics in the respective AFEL-deliverables.

Potential entries can be proposed by any involved co-worker and all AFEL members are invited to participate in enlarging and improving the glossary. Ideally, it will build a bridge from abstract psychological concepts to concrete data science scripts and procedure for studying and operationalizing these constructs.

Table of Contents:

Aim and Purpose **1**

Theories and (Cognitive) Models **4**
- Metaphors, Models, Theories 4
- Cognitive Model 4

Knowledge and Learning **5**
- Knowledge 5
  - A Working Definition of Knowledge for AFEL 5
  - Textures of Knowledge 5
  - ‘Justified True Belief’ and the ‘Knowledge Acquisition Metaphor’ 5
  - Knowledge as a Social Phenomenon and the ‘Participation Metaphor’ 7
  - Knowledge Construction and Knowledge as Discovery 7
  - Meaning 9
  - Formal and Informal Learning 9
- Learning and Knowledge Creation 9
  - Productive Friction 9
  - The Co-Evolution Model of Learning and Knowledge Construction 10
- A Working Definition of Learning for AFEL 11

Artifact Characteristics **12**
- Topic 12
  - Topic Scope 12
- Text readability 12
- Popularity 13
- Complexity 13
- Heterogeneity/Similarity 13
- Controversiality 13
- Bias 13
- Difficulty 13
- Cross-resource relations 14
- Presentation and Visualisation 14

User Characteristics **14**
- Traits and States 14
  - Mood states 14
- (Cognitive) Effort 15
- User Data 15
  - User profiles 15
  - Cognitive development/trajectories 15

Learning objectives 15
Social status indicators of the user 16
Social Graph 16
Relations to resources 16
Learning Success / Learning Outcomes 16
Traits and States 16
Mood states 16
(Cognitive) Effort 17
Personality 17
The Big Five Personality Dimensions: 17
Motivation 18
Achievement Motivation 18
From handling complexity to motivation 19
Intrinsic and extrinsic motivation 19
Interests 19
Competence 19
Opinion 19
User-Artifact-Interactions 20
Browsing Activity 20
Learning Activities 20
Learning Scope 20
Learning Trajectory 21
Self-organisation 21
Self-organization in social systems 21
Self-organisation in social media communities 21
Self-organisation in Wikipedia 22
Echo Chamber Effect 22
Achievement Priming 23
Internet-Communities 23
Definition: Communities 23
Community Detection 23

Theories and (Cognitive) Models

Metaphors, Models, Theories

A theory is a system of ideas and statements (such as e.g. definitions, operationalizations, assumptions about causal influences, …) that allow for conjectures of the kind ‘A => B’ (prediction; explication) and apply to a potentially unlimited set of concrete empirical cases (generativity).

A Metaphor or a Model (in this sense) is an oversimplification of reality as means of making some features or characteristics of a complex system understandable => metaphors and models are ‘always wrong’, because they are deliberate oversimplifications, whereas theories could potentially ‘be true’.

Hence, when we talk about metaphors of learning, we are aware that these metaphors are oversimplifications that serve the function to make a certain notion evident; metaphors can be helpful or appropriate in certain context with regard to certain aspects of a complex ‘truth’ (whatever that is).

Cognitive Model

Model (see above) of the cognitive processes (thinking, memory, …) that are involved in a certain learning activity / that are needed to successfully solve a learning task. Whereas it is possible to formulate very detailed and precise models for specific learning tasks, a model that is meant to explain a phenomenon such as everyday learning in its entirety needs to be very broad and abstract. An example for a narrow model would, for example, a cognitive model of the steps and requirements for 4th-graders to learn the mathematical concept of multiplication. Throughout our project, we will use the Co-Evolution Model of Learning and Knowledge Construction (see below) as an abstract higher level framework to ensure a common understanding of broad terms such as knowledge and learning.

Knowledge and Learning

Knowledge

A Working Definition of Knowledge for AFEL

The term 'knowledge' denotes the factual claims which are held to be true within a given community.

Rather narrow definition, but allows for discerning between knowledge, values, and attitudes etc. If we use this definitions, learning how to ride a bicycle is not the acquisition of knowledge, but that is not necessarily bad (see below).

This definition refers to what is sometimes called declarative knowledge, that is knowledge about facts. Often, procedural knowledge is differentiated from declarative knowledge, that is knowledge on how to do things (e.g. skills or proficiency in some activity) and how things are done (including norms and scripts etc.). For example in Bereiter's and Scardamalia's knowledge building approach, there is the assumption that for most relevant forms of knowledge both declarative and procedural knowledge are needed.

It is also possible to differentiate between explicit and tacit knowledge. Tacit knowledge is knowledge that we don't know to have and which we cannot verbalize that easily. Most tacit knowledge is rather procedural knowledge.

Textures of Knowledge

Partly knowledge seems to be a social phenomenon. If we adopt a constructivist position, we may consequently believe that there are different 'textures' of knowledge – often within the very same domain or topic: Some knowledge elements are uncontested and shared by (almost) everyone within a 'knowledge community' (facts). On the other hand side, there is contested knowledge: Different social groups regard different beliefs as true and justified (opinion, attitude), these beliefs do refer to factual claims. On the other hand, some knowledge may be fragile in the sense that at the present time, there is no generally agreed consensus because of a lack of data (under-determination) or contradictory data (over-determination). Finally, more abstract and comprehensive systems of beliefs can come into play. In parallel, some knowledge elements are more central or peripheral for a given topic to others.

'Justified True Belief' and the 'Knowledge Acquisition Metaphor'

Since Plato, knowledge was 'traditionally' defined as 'justified true belief'.

- Justified: Based on 'accepted and reasonable' procedures of knowledge acquisition (not just a guess etc.).
- True: Correspondence with the 'facts' (of course a very difficult topic of its own).

- Belief: Still, even justified true beliefs can possibly be wrong.

Problems with this definition:

- Individualistic (knowledge is just something ‘in the head’; social component is missing, but who determines which procedures are ‘justified’ and which are not? => to a certain degree, knowledge is always a social phenomenon).
- Static (knowledge is true or not and it is what it is and doesn’t change).
- How do we create new knowledge? Knowledge is / has always been ‘there’ and can just be discovered.
- This definition may transport a rather naive notion of ‘facts’.

The corresponding metaphor of learning to this definition of knowledge as a rather static belief that corresponds with the facts is the ‘knowledge acquisition metaphor’.

The acquisition metaphor implies that learning consists in the accumulation of “basic units of knowledge” within the “container” [Sfa98, p. 5] of the human mind. These units exist independently from learners and teachers. Once acquired, knowledge can be developed, transferred, transmitted, and grasped similar to other physical goods. Even in “moderate to radical constructivism”, the acquisition metaphor is used frequently. Though learning is conceptualized in these approaches as a “never-ending self-regulated process of emergence in a continuing interaction with peers”, the “essence” (p. 6) of what is to be learned is still something that can be acquired, transferred, and developed. [D4.1 p. 7]

Knowledge cab acquired from persons (e.g. teachers), artifacts (e.g. textbooks), or by means of observation.

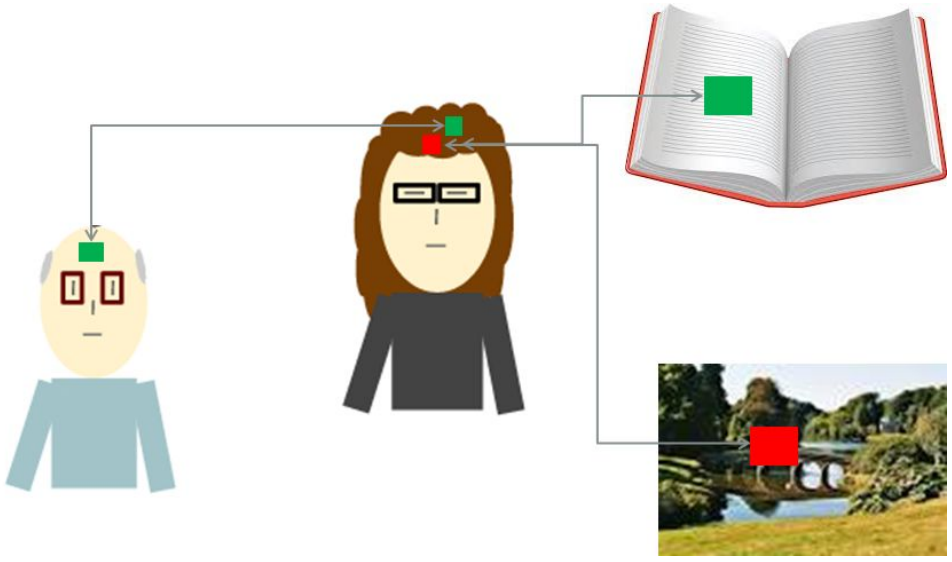


Figure 1: Knowledge Acquisition

Knowledge as a Social Phenomenon and the ‘Participation Metaphor’

Sfard´s [Sfa98] analysis of the participation metaphor reveals that here frequently the noun *knowledge* is replaced by the verb *knowing*: Knowledge is not regarded as an object that can be developed, acquired, or transferred, it is an activity in which people can participate. These activities are connected to certain contexts within which they take place. Teachers can be understood as the “preservers of ... continuity” (p. 6) of the norms and customs of the respective community, every learner is a potential “reformer” (p. 6). Here, learning is a social process: The outcome of learning is the enculturation of the learner into a community of practice [LW91]. [D4.1 p. 7]

Problem:

- In this approach, it is difficult to differentiate ‘knowledge’ from other concepts such as attitudes, values, … etc.
- Self-directed and casual learning may be difficult to fit in (only if you assume that here the culture is mediated via the artifacts..

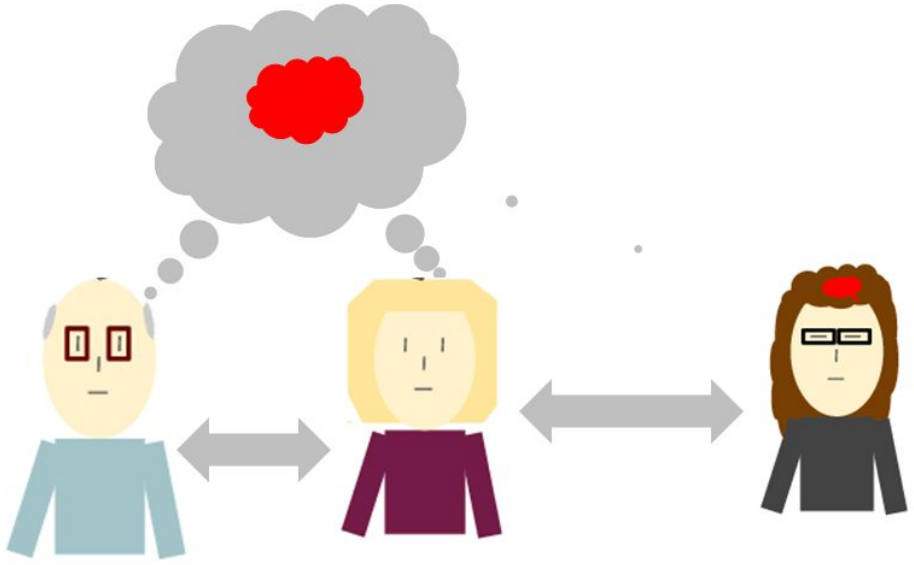


Figure 2: The participation metaphor.

Knowledge Construction and Knowledge as Discovery

In 2004, Paavola, Lipponen, and Hakkarainen [PLH04] argued in favor of the need for a third metaphor of learning: The knowledge creation metaphor. In their seminal paper, they synthesize three different approaches to a more social and constructivist conception of knowledge: Nonaka and Takeuchi’s [NT95] model of *knowledge creation*, Engeström’s [Eng99] model of *expansive learning*, and Bereiter’s [e.g., Ber02] model of *knowledge building*. [...]

One characteristic of all these approaches is the “pursuit of newness” [PLH04, p. 562]: Knowledge is not some *object* that can be acquired; it is neither the acculturation into an

existing community of practice [WS00]. It is the creation of something. Of course, newness does not equal chaos or randomness. Knowledge creation—be it in the classroom or in work and organizational contexts—builds upon existing knowledge and in many cases, knowledge will be re-created in view of the *constraints of reality* that constitute the limits of what *can* be created in a given situation. [D4.1 p. 7-8]

In the knowledge construction metaphor, knowledge results from interactions between a learner and the environment (persons or artifacts); for example, attempts at problem solving will result in knowledge (this is the backbone of e.g. Popper's philosophy of knowledge, see D4.1).

Advantage: Modern and fits in well with digital environments.

Possible problem: Sometimes, it may overly complicate matters (the other two metaphors are simpler and in many cases may describe better the phenomena we are investigating).

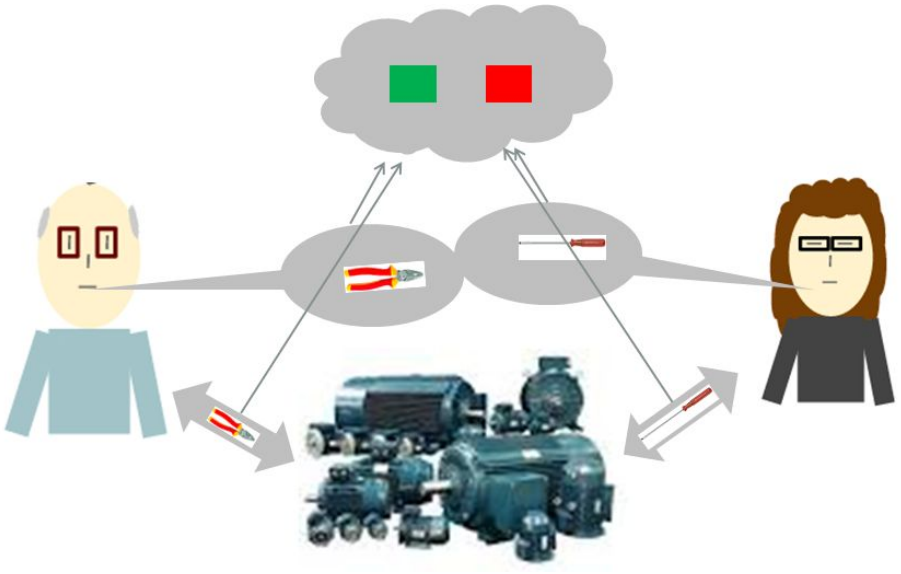


Figure 3: Knowledge construction

The knowledge construction metaphor and the notion of learning being the result of interactions between a learner and the environment (in a digital environment, mediated through digital artifacts), guides our concept of relevant entities within the AFEL-project.

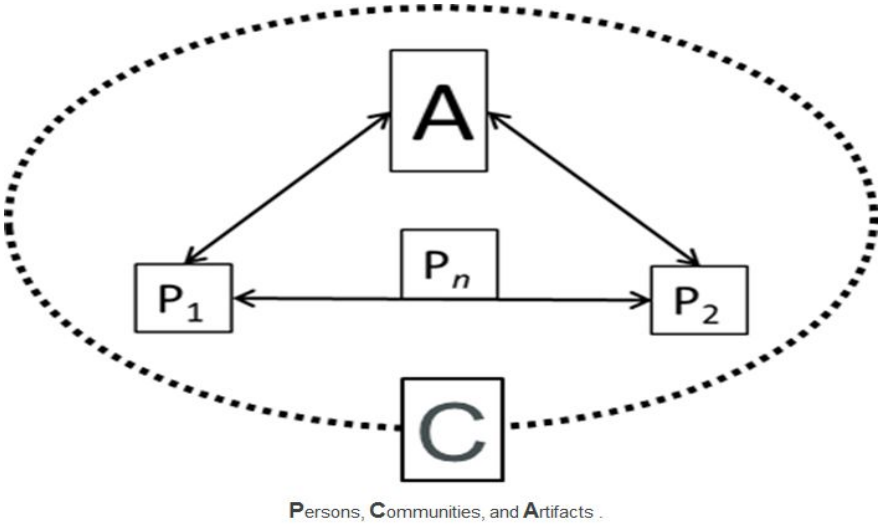


Figure 5 (D4.1): Entities

Meaning (no link a.t.m.)

In general terms, ‘meaning’ is on the one hand what is conveyed explicitly or implicitly and intentionally or unintentionally in an act of communication; on the other hand, the term ‘meaning’ is an “implication of a hidden or special significance” (https://www.merriam-webster.com/dictionary/meaning). One of the main differences between the terms meaning and knowledge is that meaning does not imply truth in an objective sense. However, agreement upon meanings (for example, with regard to concrete objects or abstract ideas) is a precondition for discussing the truth status of propositions. (D4.4 p.7)

Formal and Informal Learning (no link a.t.m.)

Informal learning is defined by its contrast with *formal learning*. Previous work [MK01] defines informal learning as: “*Formal learning* is typically institutionally sponsored, classroom-based, and highly structured. *Informal learning*, a category that includes incidental learning, may occur in institutions, but it is not typically classroom-based or highly structured, and control of learning rests primarily in the hands of the learner.” (D 2.3)

Learning and Knowledge Creation

Productive Friction

One central element of all models of knowledge construction and of the co-evolution model is the idea that ‘productive friction’ drives learning processes: Only if we encounter something new or unexpected and if we integrate this information into our existing cognitive structures, we can learn something new. Expected and beliefs confirming information only leads to a deepened belief in what we believed to be true, anyway. However, when given the choice, human beings ‘always’ prefer information that is consistent with their beliefs (this

phenomenon is known as ‘confirmation bias’, [JSFT01]). Hence, confirmation bias can (and presumably does quite often) stand in the way of learning. This may for example lead to the very unwanted echo chamber effect [DBZPSCSQ16]: When given the choice, individuals prefer to form internet communities with like-minded people. Given that access to information is more or less unlimited, these communities can then only select and perceive consistent information; this may over time lead to more and more isolated, disengaged, and radical communities (and not to learn because of a lack of productive friction; see below => Echo Chamber Effect). [D4.1 p. 18]

There have been quite a lot of empirical studies on the importance of friction for learning processes (see D4.1). And already the bible says so: *“For in much wisdom is much grief: and he that increaseth knowledge increaseth sorrow.”* (Ecc, 1:18).

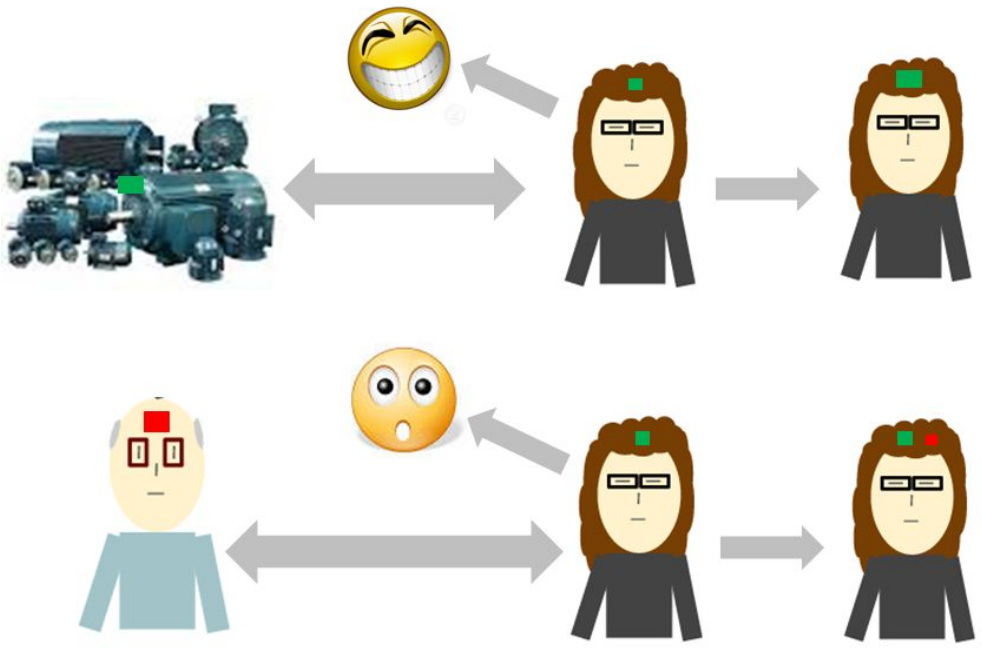
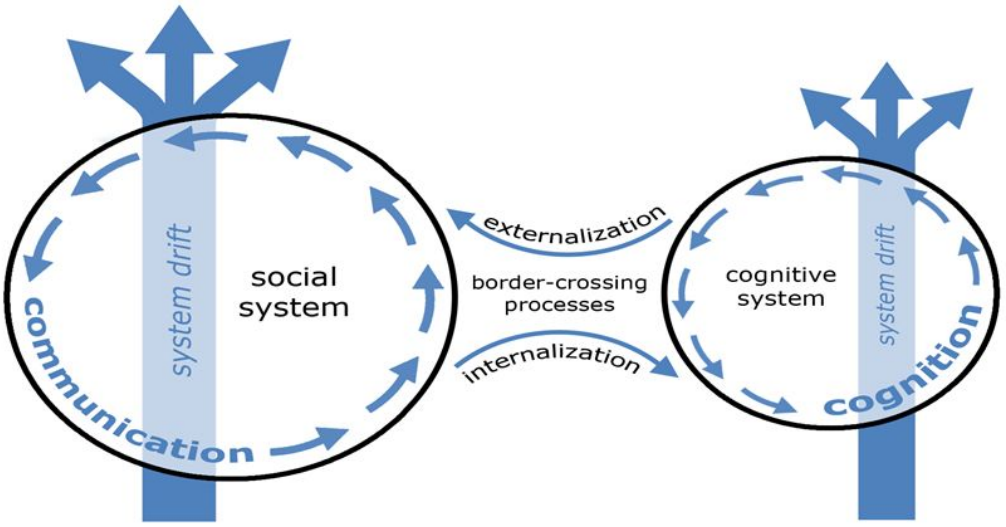


Figure 6: Productive friction

The Co-Evolution Model of Learning and Knowledge Construction

This Model is our main theoretical framework. Here individual learning and collective knowledge construction both result from the interaction of two operationally closed systems [CK08]: On the one hand, the cognitive systems of human beings with the modus operandi of thinking; on the other hand, a social system with the modus operandi of communication. In this tradition, the co-evolution model of learning and knowledge construction (Cress & Kimmerle, 2008) treats learning on the side of individuals and knowledge construction on the side of communities as two structurally coupled processes: Irritations of a learner’s cognitive system in form of new or unexpected information that has to be integrated into existing cognitive structures leads to learning processes in form of changes in the learner’s cognitive schemas, behavioral scripts, and other cognitive structures. In turn, such learning processes may trigger communication acts by learners within knowledge construction communities and stimulate further communication processes that lead to the construction of new knowledge. In this model, shared artifacts, for example in form of digital texts such as contributions to

wikis or social media messages, mediate between the two coupled systems of individual minds and communicating communities (Kimmerle, Moskaliuk, Oeberst, & Cress, 2015). (LAK-Paper)



A Working Definition of Learning for AFEL

Learning is the acquisition of knowledge, skills, (behavioral) norms, competencies, values, … as a consequence of interactions between a learner and the environment. Learning something new requires 'productive friction' - that is incongruities between a learner's concepts/schemes/scripts and the environment.

This definition should cover cultural knowledge and the participation metaphor as well: This is learning something through encounters with members of a community. If we use a dynamic concept of knowledge, our concept of learning is dynamic as well (knowledge may change). In the co-evolution model, learning and knowledge construction are structurally coupled, anyway.

- In digital environments, encounters between learners and artifacts are pivotal.
- For a growth of knowledge in the sense of learning something new, productive friction in the sense of encounters with hitherto unknown 'things' is needed.
- Learning is always to some degree bound to a social context (knowledge community; community of practice, …)

Artifact Characteristics

Topic

As the construction of a topic model exceeds the scope of the project, due to the breadth of informal learning, topics will be captured only in relation to other data categories, resources being one. (D1.1)
Topic can obtain as a cluster resources based on topics e.g. Title and Tags attributes could be analysed (D1.3)

Topic Scope

From the LAK-Paper: As mentioned in the previous section, we aim to test the approach presented in this paper in the context of browsing activities, where the scope of learning is straightforwardly represented as a topic of interest to the learner. We therefore define a TopicScope as:

$$TopicScope \equiv Scope \cap \ = 1 \ target.Topic \cap \forall includes.Topic \quad (5)$$

In other words, a TopicScope is a scope which targets a main topic, and includes sub-topic. In the BrowsingAFEL ontology, we represent topics in a way to include also a measure of the prominence of included topics within a given scope as this is used to in the section below to calculate the contribution of each activities to a given scope.

=> Specifity

- Topic familiarity: Familiarity with a topic, in general, helps people to create personal associations with the subject leading to less cognitive load and thus better performance. This phenomena is also observed in online communities such as Wikipedia. Familiarity with Wikipedia articles was reported to result in more semantic comprehension of the content (Lucassen & Schraagen, 2011) and more and longer edits (West et al., 2012).
- Topic controversiality: Topics that create controversies attract more attention and lead to long conversations, editor activities, and growth of communities (Sobkowicz &Sobkowicz, 2010; Wilson & Likens, 2015). It is most likely that by engaging with controversial topics on online platforms, people get the chance to express their opinions on hotly debated issues.

Text readability

Readability formulas have been introduced to predict the level of comprehension for large passages of texts in a document. The level of comprehension of texts is linked to the prediction of the required level of reading skills to easily use and understand it. The readability of a text depends on its content and presentation (e.g., font and size). In this particular context, the literature proposes a wide range of readability formulas such as

Flesch–Kincaid readability tests, the Gunning Fog Index,the SMOG Grading Index, etc. The current version of the Didactalia Learner Dashboard uses the SMOG Grading Index in order to compute the complexity indicator. However, relying on a similar method as for topic coverage, we are currently experimenting with more advanced approaches for complexity, not only relying on the syntax of the text, but also on how specialised the notions mentioned in the text are (using in particular their location within the category hierarchy of DBpedia).

Popularity

Popularity is an indicator in the data source taxonomy. It is thereby a more objective measurable size or resource and is used as a justification for different user characteristics.

For example Popularity is an indicator of the social status of a user:
“Depending on how topic focused a platform is, the popularity of a user on that platform, coupled with their background and skills, contributes to qualitative assessments of both the learning resources they contribute to, and their involvement with learning processes.” [D1.1]

Popularity is an indicator for Competency wrt. learning outcomes. [D1.1]

Measuring Popularity:
Popularity and authority indicators are: Shares, Citations, Ratings, Cross-references [D1.3]

“Understanding provenance and authoritativeness will be useful to assess the expected value/quality of the resource and also to explain complementary indicators of popularity and usage.” [D1.1]

Complexity

In the case of textual resources, complexity will most often be co-extensive with readability.

Coverage

Diversity

Heterogeneity/Similarity

Heterogeneous documents display differences in terms of concepts and ideas, although they are related to the same overarching topic. Similar documents comprise of similar concepts and ideas.

Controversiality

Controversiality entails a variety of viewpoints with regard to a topic. As means of operationalizing it, we would first have to identify topics within a variety of web documents expressing opinions (e.g., postings and tweets); then, we would have to identify central concepts and arguments to develop measures of => heterogeneity.

Bias

Bias can arise within a => controversial topic whenever central arguments and aspects that are considered pivotal by a majority of users are missing and/or whenever other arguments and aspects are introduced that are not considered to belong to the given topic. Fact checkíng software is designed to identify biased resources.

Difficulty

In case of games, we can derive a proxy for a game's difficulty through the percentage of users that have successfully completed a game. From data on an individual learner's success or failure in games, we can then derive a measure for his/her => ability in solving these games in comparison to other learners. If all the cames can be related to the same => topic and => learning scope, we can derive a competence measure for the learner with regard to the given topic.

Cross-resource relations

?

Presentation and Visualisation

=> To be connected to the WP3 deliverables on Visualisation.
Communities in a Learning-Graph Visualization Framework

- Visual Encoding in Dynamic Node Link Representations
- Graph-Vis Framework Approach
- Communities in GVF

Visual Analytics Dashboard for Supporting Learning in Communities

Visual Metaphors for Conflicts, Problems and Barriers

User Characteristics

User Data

Data that identify or otherwise describe *individual* agents who participate, in actuality or potency, in learning activities, as well as their possible relationships with learning environments and reasons for inclusion therein.(D1.1)

There are a lot of User-based features in the D1.3 to measure User Data. Some of them are briefly described here as well:

User profiles

Examples: basic personal information on users and (potential) learners, psychographics/IAO variables, and statically-defined characteristics of their background and skillset (i.e. those whose development is not known). (D1.1)

Cognitive development/trajectories

Scholarly background; skills and knowledge that a user has acquired or is in the process of acquiring, as well as the evolution of a user's interests over time. (D1.1)

Learning objectives

Tbd by Work Package 1

Social status indicators of the user

Data related to the status that a user has reached in the social orders that are defined, directly or indirectly, by the systems the user interacts with. For instance, quantitative metrics of how popular or influential a user is. (D1.1)

Social Graph

Specification of groups, communities and societies, both real-life and virtual, where a user participates, thus forming the user's social graph. Also, collaboration graphs such as co-authorships are included. In the case of online platforms, this generally denotes groups formed within the platform itself. (D1.1)

Relations to resources

Any accounts of a user playing a role in the life-cycle of a resource used for informal educational purposes (described later in DT2); for instance, which resources have been authored, edited, rated or commented on. The information objects that realise the relations, such as the edit history, scores given and comment texts, are outside the remit of this category and are treated in other members of the taxonomy. The time-indexing and general contextualisation of these roles is optional in this data type.

Learning Success / Learning Outcomes

A learner successfully acquires the knowledge, skills, (...) he/she wanted to acquire. Can be operationalized by means of measuring competence gains or by means of self reports e.g. via questionnaires.

Traits and States

- **Traits** (*Eigenschaften; e.g. personality traits, see above)*
    - Are **user specific**
    - Do not change
    - Highly generalizable (affect a number of different situations).

    - e.g an *eccentric* person
- **States** (Aktueller Zustand)
    - are **activity specific** (not independent from time and context like traits)
    - they are resulting from a combination of the user's traits and the current activity.

Mood states

Particular mood states that people experience in a given situation affect their contribution to and participation in the online communities. Content of the presented knowledge could influence users' mood states and lead them to act in certain ways in terms of processing and contributing to the knowledge. For instance, Wikipedia content covering threatening events (e.g., earthquakes, terror attacks) that lead to negative mood states in people have an impact on their contributions to Wikipedia articles (Greving et al., in press). Online environment itself might also be triggering the mood states. Any content encountered on the Internet (e.g. social media content, pop-up ads) has the ability to change Internet users' online behavior patterns, including contribution to online knowledge. Two factors which have substantial influences on online (learning) behaviors are explained below:

- Mortality salience: As the primary survival concern, mortality salience is induced by various cues in everyday situations and affect mood states and behaviors in various ways. Internet users often come across death-related content which evokes their mortality awareness, and such content changes their online behavior patterns (Chopik and Edelstein, 2014), and motivation to engage with online knowledge communities.
- Uncertainty salience: Uncertainty is confronted almost on a daily basis in the form of rapid changes and unpredictability in personal, occupational, and political worlds (Van den Bos, 2001). Uncertainty of online environments (Pavlou et al., 2006) as well as the presented knowledge in the online communities (e.g. Wikipedia articles) that deal with the phenomena that are themselves uncertain or unpredictable to a certain degree (Vincze, 2013) yield changes in individuals' mood states and thus learning behaviors in online communities.

(Cognitive) Effort

Effort is the subjectively experienced strain from an activity. Effort can be measured either by means of self reports (how much strain did you experience …) or by means of physiological measures (e.g. oxygen uptake; heart rate). If the complexities/difficulties of different tasks are known, one can also try to derive the subjectively experienced strain (latent variable) from the objective difficulty of the material. See e.g. http://arrow.dit.ie/cgi/viewcontent.cgi?article=1010&context=scschcombk

Personality

Personality refers to the most abstract, general, and elemental level of individual differences in behavior and thinking. One could say that personality has an effect on everything a person thinks, does, and feels - but always a rather small one compared to more narrow and domain-specific traits and characteristics.

In psychology, five-factor models of personality are commonly used and very popular (see e.g. for an overview https://en.wikipedia.org/wiki/Big_Five_personality_traits). Research by the group of Kosinski and Stillwell (see e.g. http://applymagicsauce.com/) has shown that it is indeed possible to derive personality traits from behavior traces at Facebook such as status updates, postings, and likes. We could use their algorithms for language in short informal texts (e.g. postings) to estimate personality features of contributors to the platforms we analyze. (D2.3)

The Big Five Personality Dimensions:

- *Extraversion*: activity and energy level traits, sociability and emotional expressiveness.
- *Agreeableness*: altruism, trust, modesty, and prosocial attitudes.
- *Conscientiousness*: Impulse control, goal directed behavior.
- *Neuroticism*: Emotional stability, anxiety, sadness, and irritability
- *Openness*: Breadth, complexity, and depth of an individual's life.

Motivation

Motivation is what drives people to do something. Sometimes, we differentiate in psychology between 'push' and 'pull' factors in motivation. Push motivations arise from the desire to satisfy needs such as autonomy, attachment, relatedness, success … The most basic and abstract level of these needs (comparable to the level of personality with regard to interindividual differences) are the "big three" needs of affiliation, achievement, and power/autonomy. There have been empirical studies that showed that interindividual differences regarding these basic needs can be predicted from behavior traces such as short informal communication (postings etc.). The LIWC software has word scales referring to these basic needs.

Pull motivation arises from the wish to achieve goals. More often than not, pull motivation is stronger than push motivation. If we have clear statements of goals, we now quite a lot about a learner's motivation. If not, we can try to extract information on goals from behavioral traces (like the intensity/frequency of engagement with difficult artifacts).

Motivation is usually defined in psychology in the tradition of Kleinginna and Kleinginna [KK81] as "an internal state or condition (sometimes described as a need, desire, or want) that serves to activate or energize behavior and give it direction" [Hu01]. Franken [Fra06] additionally emphasized that motivation is arising the direction and persistence of behavior. It is most basically the answer to the question why people do what they do. From the early 20th century on, psychologists have empirically studied the relationship between motivation and learning [e.g., YD1908]. Not only are certainly motivational states related to certain types of learning behavior and certain learning outcomes; learning itself in turn also motivates future behavior. (D4.3)

Achievement Motivation

Achievement motivation can be defined as the need for success or attainment of excellence. A number of prior works in psychology have studied achievement motivation. McClelland first

proposed that achievement motivation may be understood as a motivational process that involves the regulation of different social goals. This was supported by more recent research corresponding to goal pursuits.
The goal to achieve is an alternative to the goal to have fun or indulge in leisurely activity. The authors show that people choose to pursue excellence (at the expense of having fun) or pursue fun (at the expense of achieving) depending on their level of chronic achievement motivation (the amount of pleasure in achieving goals). People with high chronic achievement motivation exhibit goal-seeking behavior when they encounter motivational triggers, while those with low chronic achievement motivation exhibit a fun-seeking behavior in such cases. (D2.3)

From handling complexity to motivation

The handling of complexity as it is conceptualized within the co-evolution model and motivation are intertwined processes. Motivational states can be conceptualized in this context as results of the interaction between the cognitive system and the surrounding social system. Apart from basic 'homeostatic' needs such as the need for food and sleep, all higher order needs such as the need for certainty, the need for belonging, the need for esteem, and the need for self-actualization can be understood as being the results of comparisons between 'is' and 'target' values within the cognitive system. Whenever the 'is' value of a certain motive is too far below the respective 'should' value, there will be motivation to restore satisfaction by means of activities that restore the balance. (D4.3)

Intrinsic and extrinsic motivation

Motivation that results from motivators within a person is usually called intrinsic motivation whereas motivation through external sources is usually called extrinsic motivation. It should be noted though that in most cases motivation is the result of the interplay between intrinsic and extrinsic factors (D4.3)

Interests

We can define interests as topics (or domains of topics) that play a prominent role in a person's (online) activities. Given enough data, we can probably predict a person's interest relatively well from e.g. browsing behavior (as is done in online marketing over and over). Here, it is important to classify different activities as belonging to certain domains.

Competence

Usually defined as the ability to do something successfully. In our context, this can refer to successfully dealing with digital artifacts. Indicators of success can of course be quizzes and tests (that is the easiest case). In cases when users take such tests at several points in time, we can study growth of competence.

Other indicators of competence could be the derived from the complexity (=>) of the materials a user interacts with (maybe in relation to the time spent with these artifacts; just opening a website and closing it right away is probably not an indicator of success). Within a learning trajectory on a given learning scope, competence trajectory could be assessed this way.

Opinion

Within our framework, it is not easy to differentiate an opinion from knowledge apart from the fact that an opinion does usually not entail as strong a claim for correctness or truthfulness as is required for knowledge. However, our framework also allows for conceptualizing a change of opinion as learning, if this change increase the cognitive system's ability to cope with disturbances.

User-Artifact-Interactions

Connections with AFEL-Ontology

Browsing Activity

$$BrowsingActivity \equiv Activity \cap \exists uses.OnlineResource \quad (4)$$

I.e. that a BrowsingActivity is an activity that uses an online resource (to simplify). An OnlineResource is defined as a resource that is accessible through a URL [LAK-Paper].

According to D1.3 Browsing can be the activity to navigate to other contents, to browse to a new search, to follow a pre-established learning path/graph or to browse/navigate through entities. (Searching and Browsing)

Learning Activities

All activities – intentional or not and conscious or not – that can lead to encounters that can trigger learning processes.

$$LearningActivity \equiv Activity \cap \exists contributesTo.LearningScope$$

In other words, a *LearningActivity* is an Activity which contributes to at least one of the learner's *LearningScopes*. Obviously, this definition is very much dependent on the definition of other concepts. A *LearningScope* is in particular a key notion. The idea here is similar to the one of ``EducationalAlignment'' [Ref] but for learners rather than resources: It represents the purpose of a learning trajectory, which might take the form of a learning objective, a learning goal, or simply, as in our experiments, a (set of) topic(s) [LAK-Paper].

Learning Scope

$$LearningScope \equiv Scope \cap \exists scopeOf.LearningTrajectory$$

A LearningScope is therefore generically defined in the following way: In other words, it is a Scope (which is an atomic concept that might be specialised differently depending on the context) that is the scope of a LearningTrajectory. Before focusing on the LearningTrajectory concept, we also need to specify what is the relation between a LearningScope and a

LearningActivity. Generally, in this ontology, an Activity can be within a Scope, but to be a LearningActivity, as described in Equation~1 above, it has to also contribute to the scope. Again here, how an activity is contributing to a scope is highly dependent on the context and can only be defined generically. However, it is meant to encapsulate the idea that the LearningScope at a given time represents the state of the learner's ``cognitive system'' and that contributing means generating an ``irritation'' in the form of ``new or unexpected information''. In our experiment below where a LearningScope represents topics being learned about, for an activity to contribute means that it introduces new sub-topics within the LearningScope. [LAK-Paper]

Learning Path/Trajectory

A learning trajectory comprises "… the learning goal, the learning activities, and the thinking and learning in which the students might engage" (Martin Simon, 1995, p. 133) = what happens inside and outside the head: Sum of all interactions and the processes that are triggered by these interactions

What was called a learning trajectory in the LAK-paper (the totality of all learning scope related activities), should maybe better be called a learning path, at least as no latent user characteristics (experiences, competency gains …) are taken into account [LAK-Paper].

$$LearningPath \equiv ActivitySet \cap \forall includesActivity.LearningActivity \cap \exists hasScope.LearningScope$$

Self-organisation

Self-organization in social systems

If we look more specifically at knowledge communities as social sub-systems, self-organization entails on the one hand processes of filtering out information that is not processed within the respective social system. As means of ensuring the system's survival, which depends on common sense and shared understanding, a system can only 'digest' a certain amount of information that defies socially shared structures of meaning. Hence, we hypothesize that every knowledge community in so far as it constitutes a societal sub-system, will devise mechanisms to reduce the amount of non-processable information to a tolerable limit. Presumably, this limit is related to a system's flexibility and its ability to deal with friction in a productive way. On the other hand, social systems will also develop specific means of processing information in a way that constitutes socially shared meaning among its members.

Self-organisation in social media communities

Since the emergence of the internet as a mass phenomenon, several theoretical frameworks for the regulation of behavior on the internet have been developed. One of the most influential approaches is Lawrence Lessig's 'pathetic dot theory'. Here, four factors are at play in regulating human beings' behavior inside and outside of cyberspace [see Figure 2]: One is the 'architecture', or in the case of the internet, the 'code' in the sense of what actions are made possible or 'allowed' by the 'technical infrastructure' and which are not. For

example, possible interactions between users and Facebook are limited by means of Facebook's software architecture. A corresponding way of regulating behavior in the 'real world' would be, for example, the restriction of access to certain areas by means of doors and fences. Behavior on the internet (and outside of it) is regulated as well through the 'forces of the market' or supply and demand. On the other hand, there are implicit and explicit rules or, in other words, social norms and laws that regulate behavior. In internet communities, the term 'law' can on the one hand refer to the 'actual' law in a given state or the explicit rules and regulations that the operators of the webpage defined. In the case of social norms, Kittur and Kraut further differentiated this aspect of regulation into implicit and explicit coordination. Explicit coordination relies on communication regarding specific aspects or the website's general policy. Implicit coordination concerns the acceptance and effective execution of the respective rules by means of unspoken expectations and shared knowledge. Such implicit coordination has been found to be particularly effective whenever a high number of contributors is involved.

Self-organisation in Wikipedia

An extensive analysis of processes of self-organization in Wikipedia can be found in D4.2.

Echo Chamber Effect

The ubiquitous availability of information in the age of social media and the personalization of information flows can apparently under certain circumstances facilitate an exposure to more diverse viewpoints (e.g., Messing & Westwood, 2012) whereas in other cases, they can lead to the emergence of "filter bubbles" minimizing exposure to attitude-challenging information (e.g., Pariser, 2011) or so called "echo chamber effects" (e.g., Scruggs, 1998): Like-minded individuals share among themselves attitude-confirming pieces of information and filter out alternative viewpoints; this may, on the long run, lead to increasing radicalization, increasing cohesion within the group, and increasing detachment fromother communities. In our studies, we analyze the interplay between processes on the levels of technology, social groups, and individual minds.

In our models, we will take into account filtering processes on three different levels. The first group of filters - algorithms - operates on a technological (macro) level: Online media providers, such as Google or Facebook, filter information according to users' assumed wants and needs often using non-transparent, automatic algorithms. On the other hand, such recommender systems constantly confront the user with previously unknown novel information to maximize click-through rates thereby potentially increasing the exposure to different points of view. The second group of filters - group dynamic communication processes – works on a meso level: Well researched processes, such as group-think and group attitude polarisation can, under certain conditions, lead to increasingly similar attitudes of individual group members that tend to be extreme and very different from those of other groups. On the other hand, a majority influence should lead users to comply with and internalize information that corresponds to the (perceived) majority view. The third group of filters - individual cognitive motivational processes - works on the micro level and has been studied extensively in cognitive and social psychology. Inter-individually differing

characteristics such as conformity, need for identity confirmation, dissonance reduction and tolerance of ambiguity influence information search, processing and memory, and thus, attitude formation. To boost social identity, to confirm pre-existing attitudes, to avoid cognitive dissonance and to confirm their world-views, individuals are differentially cognitively motivated to search for and add fitting and to ignore or deny conflicting information, that they filter accordingly. On the other hand, curiosity may motivate individuals to preferentially consume information that is at least to some degree novel and surprising.

Achievement Priming (no link a.t.m)

Techniques to subtly activate achievement related thoughts and ideas. In consequence, learners are supposed to display higher degrees of => Achievement Motivation after receiving subtle cues such as processing achievement-related words.

Internet-Communities

Definition: Communities

Aggregations of users that have some activity in common, e.g.:

- They communicate with each other
- They are interacting with the same artifacts
- They are interested in the same topics
- Express similar attitudes towards facets of the respective topic (similar ideology => overarching attitude patterns comprising values etc. as well, which is of importance to the members social identities).
- ...

New knowledge arises within communities from irritations of the social system through expressions of ideas (...) of individual contributors (irritation by the cognitive system).

Community Detection

In informal learning environments, individuals form groups or communities that are characterized with persons sharing common interests, beliefs or opinions for a certain topic or issue.
In the graph theory and network science, communities in a network are characterized as (overlapping) sets of nodes, which are densely connected internally [Luh95].
In some use cases, group or community membership of the user is made explicit (i.e., user registration to a particular community). If this is not the case there are algorithms and methods to detect potential communities in a network [F10]. One of the widely used algorithms is the stochastic block-model algorithm [KN11]. One advantage of this approach is that it attempts to find a block partition without the need to specify the partition size in advance. (D1.3)